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Effect of *Chlorophytum Comosum* Growth on Soil Enzymatic Activities of Lead-contaminated Soil

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Abstract

Through determined the activities of urease, phophatase, invertase and catalase by pot-planting, we researched the effect of Lead (Pb) on Soil enzyme Activities and *Chlorophytum comosum* on the effect of Pb- pollution soil. The results showed that Pb pollution apparently advanced the activities of catalase and invertase. Urease activities were all reduced with the increasing Pb concentration, the activity of urease appears to be more sensitive to pollution than that of other soil enzymes. The physicochemical indexes, activities of soil urease, phophatase, invertase and catalase, have responded differently between plant groups and control groups ($P < 0.05$). In conclusion, urease activity of soil can be used as the main biochemical indicators of Pb-pollution soil. *C. comosum* demonstrated outstanding repairing effects in Pb-contaminated soil.

Keywords:Chlorophytum comosum, Lead (Pb) , Soil enzyme, Soil recovery;

1. Introduction

Although heavy metals are naturally present in soils, contamination of soils comes from mostly industry and agricultural practices, combustion of fossil fuels and road traffic [1]. With the rapid development of industry, soil environment pollution becomes an increasingly important issue worldwide [2]. Heavy metal contamination in environment by industrial emissions and agricultural chemicals has a negative effect on animals, plant and physicochemical properties of soils [3]. Pollution of the soil environment with heavy metals also negatively influences on basal soil respiration rate and enzyme activities [4] depending on the soil pH, organic matter content and other chemical properties [5, 6].

As one of these heavy metal pollutants, we must give some attention to Lead (Pb), therefore, it is

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urgent to mitigate the Pb–polluted soils. Compared to physical and chemical remediation, phytoremediation is preferred because of its safety and lower cost [7]. Nowadays ornamental plants have become a new source of phytoremediation species for they not only are used for landscaping but also have practical applications in the air pollution monitoring and control [8].

In this study, we chose one popular ornamental plant *C. Comosum* to investigate the feasibility and scientific basis for repairing the Pb-polluted soil by *C. Comosum*.

2. Materials and methods

2.1 Sample collection

The *C. comosum* seedlings with prop-aerial roots were collected from a same matrix plant. Seedlings were collected in similar growth stage and taked for the experiment one week later. The soil for test were collected from the back hill in Anhui Normal University. The soil is yellow brown soil whose pH is 4.775, the electrical conductivity (**EC**) is 107.5μs·cm^{-1}, oxidation reduction potential(**ORP**) is -150 mV, and the content of N, P and organic matter were 0.770×10^{-3}, 0.949×10^{-3}, and 4.127×10^{-3}. The soils were air-dried, grinded, and passed through a 3 mm sieve.

The soil samples were polluted artificially with 8 levels of Pb and added to plastic pots (Φ=12.5cm), 250g·pot^{-1}. The treatments consisted of CK(a soil sample with no additional Pb), 250, 500, 750, 1000, 1250, 1500 and 2000 mg Pb (in the form of $Pb(Ac)_2\cdot3H_2O$) per kilogram of dry soil. After these soils in pot equilibrated at room temperature for two weeks, two seedlings were grown in each pot. Separately, set the pot without plant served as the control group. Each treatment had three replicates.

About 90 days later, *C. comosum* was carefully uprooted, and the surface soils (0-1 mm) were shaken off and collected. The residual roots were removed, and the soil samples were air-dried, grinded, and passed through a 0.15 mm sieve.

2.2 Soil analysis

The physical and chemical properties of the soil samples, such as pH, **EC**, organic matter, and **ORP** were determined according to the Environmental Monitoring of China (1992). The soil enzymatic activities are determined as per Guan (1986). To avoid cross-contamination of Pb with other metals, all receptacles had been soaked in 2% HNO_3 for more than 24 h before used.

Data were analyzed by Microsoft Office Excel 2003 and SPSS 17.0 software package. Average values and standard deviations (**S.D.**) were calculated by the Microsoft Office Excel 2003. T-test was used to compare the otherness between different treatments and the correlation analysis and t-test were used to determine the difference among various groups of plant and soil samples.

3. Results and Discussion

3.1 Effects of Pb treatments on soil enzymatic activities

The soil enzymes are important components of soil, and soil enzymatic activities are correlated significantly with the soil fertility and efficiency of nutrition to plants. They are important indexes for determining the biological activity and productivity of soil [2]. We can Seen from table 1, phosphatase activity reached the maximum when Pb concentration was 500 mg·kg^{-1}. Pb pollution apparently advanced the activities of catalase and invertase (it reduced slightly at 250 mg·kg^{-1} Pb concentration, and then increased markedly), nevertheless, urease activities were all reduced with the increasing Pb concentration.

Compared to the enzymatic activities of CK, the inhibiting rate of urease activities were 20.77%, 25.30%, 27.32%, 30.32%, 31.49%, 32.51% and 41.37%, respectively. The promoting rate of catalase activities were 5.33%, 16.67%, 7.20%, 9.33%, 33.33%, 37.33% and 89.33%, respectively.

Table 1. Effects of Pb treatments on soil enzymatic activities

Treatment ($mg\cdot kg^{-1}$)	Invertase activity (0.1N NaS_2O_3, $ml\cdot g^{-1}\cdot day^{-1}$)	Urease activity (NH_3-N, $mg\cdot g^{-1}\cdot day^{-1}$)	Phosphatase activity (P_2O_5, $mg\cdot 100g^{-1}\cdot 2h^{-1}$)	Catalase activity (0.1N $KMnO_4$, $ml\cdot g^{-1}$)
CK	1.768±0.072a[a]	95.251±1.527a	19338.026±1074.221ab	0.375±0.035ac
250	1.764±0.101a	75.472±0.055b	21426.896±4335.250ab	0.395±0.021ac
500	1.792±0.054a	71.153±0.164c	26893.224±2436.180bc	0.400±0.071ad
750	1.802±0.026a	69.225±2.672bcdef	22946.074±6138.407ab	0.402±0.003ac
1000	1.807±0.257a	66.372±0.600d	21765.998±2896.561ad	0.410±0.014acd
1250	1.854±0.566ab	65.254±0.763de	19704.256±671.388ac	0.500±0.071acd
1500	2.302±0.176b	64.290±0.382e	17954.488±537.111bd	0.515±0.064bc
2000	2.660±0.962ab	55.846±0.218f	18293.591±57.548ab	0.710±0.014bd

[a] Values followed by different letters for a given treatment are significantly different at $p<0.05$.

Generally, Pb^{2+} can directly interact with the active functional sites of the enzymes, and change their spatial conformation. When a heavy metal replace the active functional sites of an enzyme by combining with their mercapto, amino, or carboxyl, the enzymatic activity inhibition would occur, called enzymatic passivation. Activation may also appear when the combination of enzymatic active functional sites and their substrate were improved by heavy metals. On the other hand, some heavy metals such as Cd, Pb, and Zn can also constrain soil enzymatic activities by suppressing the growth of soil microbes or depressing the synthesis and secretion of enzymes [9].

3.2 Effects of C. comosum growth on soil enzymatic activities

We can Seen from table 2, the enzymatic activities of planted groups has the same trend with the enzymatic activities of control groups. Phosphatase activity reached the maximum when Pb concentration was 500 mg • kg^{-1}. Pb pollution apparently advanced the activities of catalase and invertase (it reduced slightly at 250 mg • kg^{-1} Pb concentration, and then increased markedly), nevertheless, urease activities were all reduced with the increasing Pb concentration. That means the activity of urease appears to be

Table 2. Effects of *C. comosum* growth on soil enzymatic activities

Treatment ($mg\cdot kg^{-1}$)	Invertase activity (0.1 NNaS_2O_3, $ml\cdot g^{-1}\cdot day^{-1}$)	Urease activity (NH_3-N, $mg\cdot g^{-1}\cdot day^{-1}$)	Phosphatase activity (P_2O_5, $mg\cdot 100g^{-1}\cdot 2h^{-1}$)	Catalase activity (0.1N $KMnO_4$, $ml\cdot g^{-1}$)
CK	2.570±0.035a[a]	100.341±4.166a	24130.671±2306.108a	0.433±0.029a
250	2.542±0.086a	79.160±6.339b	24420.038±4511.143abc	0.483±0.029ab
500	2.642±0.278ac	72.169±3.678b	27386.053±6470.929abc	0.487±0.023b
750	2.706±0.389ac	72.117±4.021b	24754.619±1195.591a	0.500±0.087abc
1000	2.796±0.172ac	68.955±1.989b	22828.518±5710.230abc	0.513±0.055bc
1250	3.260±0.081bc	68.596±1.020b	20025.273±990.953b	0.533±0.058abc
1500	3.496±0.051bc	68.081±0.579b	18741.206±954.126cd	0.580±0.026c
2000	3.586±0.521ac	56.026±1.997c	18524.180±354.747bd	0.800±0.050d

[a] Values followed by different letters for a given treatment are significantly different at $p<0.05$.

more sensitive to pollution than that of other soil enzymes [10]. It was reported that urease is the most sensitive to the inhibition of single element and combined pollution of Cd, Pb, and Zn, which are some of the most important soil pollutants in China [11]. Urease activity of soil can be used as the main biochemical indicators of Pb-pollution soil.

Compared with the control group, the activities of invertase, urease, phosphatase, and catalase were all increased evidently, suggesting a significant difference between the planted and control groups ($P<0.05$) (Table 3). The increased rate of urease activities reached its peaks in 1500 $mg \cdot kg^{-1}$ Pb concentration, which are 1.058 times higher than the control groups. These demonstrating that *C. comosum* had some repairing effects on the activities of urease at every Pb concentration. We believe that *C. comosum* demonstrated outstanding repairing effects in Pb-contaminated soil.

Table 3. The Results of T-test of the difference of soil enzymatic activities between the planted group and the control group (n = 8)

Index	Invertase activity	Urease activity	Phosphatase activity	Catalase activity
T	-12.870	4.950	2.765	9.036
P	0.000	0.002	0.028	0.000

3.3 Effects of Pb treatments on physical and chemical properties of soil

Table 4 exposed the changes of the physicochemical properties of the soil in control groups under different Pb concentrations. The physicochemical properties of soil are not only the base to determine the soil quality, but also the most direct index in evaluating the recovery effect of plants. Seen from our results, it was evident that the pH values of the control groups increased gradually from 4.775 to 5.170 with the increasing Pb concentration, and the **ORP** value increased from -150 to -130 mV, accounting for 2.007%, 2.007%, 2.676%, 6.355%, 7.692%, 11.706% and 13.378%, respectively. And the **EC** vauel increased at lower Pb concentrations but decreased at high Pb concentrations. In terms of nutrient component in soil, the Organic matter did not changed much, fluctuating within a certain range.

Table 4. Effects of Pb treatments on physical and chemical properties of soil

Treatment ($mg \cdot kg^{-1}$)	pH	**EC** ($\mu s \cdot cm^{-1}$)	**ORP** (mV)	Organic matter (%)
CK	4.775±0.007ac[a]	107.5±0.707ac	-150±0.707ac	4.063±0.127a
250	4.785±0.092bc	101.0±2.828ac	-147±6.364ad	3.485±0.346ac
500	4.800±0.085bc	115.5±4.950bc	-147±0.707ac	3.715±0.000bc
750	4.845±0.078bc	127.5±2.121b	-146±0.707ac	3.760±0.079bc
1000	4.915±0.035ac	113.0±0.000abc	-140±5.657bc	3.577±0.238ac
1250	4.920±0.127ab	106.0±4.243a	-138±5.657bc	3.852±0.138bc
1500	5.020±0.028b	104.0±1.414ac	-132±1.414bd	3.669±0.079bc
2000	5.170±0.099a	102.5±3.536a	-130±3.536cd	3.715±0.000bc

[a] Values followed by different letters for a given treatment are significantly different at $p<0.05$.

3.4 Effects of C. comosum on physical and chemical properties of soil

Table 5 exposed the changes of the physicochemical properties of the soil in planted groups under different Pb concentrations. Seen from Table 4 and Table 5, the pH, **EC** and **ORP** values of the planted soils exhibited similar trend to those of control soil. The pH values in the planted soil were lower in every

Pb concentration than those of the control groups, it may be because the weak acid salt in the soil will be hydrolyzed and resulted in alkaline. Compared to the control group, the **ORP** and **EC** values in the planted soil were lower in every Pb concentration than those of the controls. The soil in plant groups was richer than the soil in control groups probably because the organic matter was decomposed by microorganisms. Table 6 showed the differences were significant ($P<0.01$) for pH, **EC**, **ORP** and Organic matter between the planted groups and the control groups.

Table 5. Effects of Pb treatments on physical and chemical properties of soil

Treatment ($mg \cdot kg^{-1}$)	pH	**EC** ($\mu s \cdot cm^{-1}$)	**ORP** (mV)	Organic matter (%)
CK	4.660±0.208acde[a]	76.0±7.211abc	-154±8.544ae	4.127±0.195ac
250	4.733±0.031a	76.3±2.309a	-150±5.774ab	3.508±0.097b
500	4.750±0.026ac	86.7±2.082b	-148±2.646adf	3.783±0.097a
750	4.770±0.035bc	77.7±6.429abc	-147±7.767bf	3.852±0.195ab
1000	4.863±0.067bd	72.3±11.676abc	-141±3.464ebg	3.783±0.292ab
1250	4.873±0.131abde	73.0±28.478abc	-139±6.557cdg	3.921±0.097bc
1500	4.940±0.046d	74.3±0.577a	-136±2.887cfg	3.646±0.097bc
2000	5.087±0.023e	81.7±1.528c	-131±0.577cf	3.783±0.097bc

[a] Values followed by different letters for a given treatment are significantly different at $p<0.05$.

Table 6. The results of T-test of physical and chemical properties of the soil between the planted group and the control group ($n = 8$)

Index	pH	**EC**	**ORP**	Organic matter
T	-8.307	-10.000	-4.000	-3.068
P	0.000	0.000	0.005	0.018

4. Conclusions

As a result, Pb pollution apparently inhibited urease activities, while the activities of catalase and invertase were both strengthened with the increasing Pb concentration. The Activitie of urease appears to be more sensitive to pollution than that of other soil enzymes. They can be used as the main biochemical indicators of Pb-contaminated soil. The soil enzymatic activities in the planted group increased significantly than those of the control group. Meanwhile, *C. comosum* can reduce soil **EC** and **ORP**. So it can say that *C. comosum* not only can bring economic benefits as one kind of ornamental plants but also be used as a plant species for phytoremediation, and it has the advantages such as high biomass, safe, low cost, little secondary pollution, etc. Therefore, there is a tremendous prospect of application for *C. comosum* in remediating Pb-pollution soils.

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